

JC18 Rec'd PCT/PTO 30 JUN 2005

WIND GENERATOR OF THE TYPE WITH AUTOMATIC POWER
REGULATION

5 Wind energy has been used for a long time by means
of rotating sails. Windmills are thus known that are
provided with wings or blades, generally four in
number; but these mills are mostly usable in countries
where the winds are more or less regular and always or
10 nearly always blowing in the same direction.

At the present time, more interest is taken in
what are commonly called wind generators or "wind
generators", devices in which the blades are metal or
made from composite materials and therefore relatively
15 non-deformable. Perfected wind generators provide
suitable efficiencies with, for example, a tail unit
forming a fin and which ensures the keeping of all the
mobile elements (for example blades) parallel with the
direction of the wind, whatever the direction of the
20 wind may be, in the so-called "feathered" position, in
order to present minimal resistance to the wind, or in
the position opposite to the feathered position, and
therefore the position perpendicular to the direction
of the wind, with in this case maximum resistance to
25 the wind. When a driving wheel is used for the correct
operation of the blades, certain devices make provision
for withdrawing this driving wheel from the wind by
presenting it sideways in the case of a storm.

Wind generators, as is known, can be used for
30 various applications: pumping water in agricultural
applications, supply of electrical energy, and also the
supply of hot water by using the heat produced when
braking the blades when it is appropriate to slow them
down for whatever the reasons may be.

35 It is important for the correct functioning of
wind generators to provide various types of
improvements; in fact on wind generators with a single
blade or with several blades, two for example, as these
blades all have large diameters, the speeds of rotation

can be very high and thus generate stresses that are difficult to control. Hence air turbines are sometimes constructed with a small rotor diameter and with a long axial length, placed at the "convergent" outlet and
5 which protects them from limiting peripheral stresses.

The present invention here relates more particularly to the adequate control of the speed of rotation of the wind generators, particularly in violent wind, that is to say when the maximum amount of
10 energy is being retrieved but the tips of the blades become too fast and threaten the soundness or at least the wear of numerous mechanical parts of the wind generator assembly. More precisely, the device of the invention relates to the automatic regulation of the
15 pitch of the propeller of a wind generator.

In the prior art, wind generators include a regulation device driven by the driving shaft of the propeller (of which a mobile regulation shaft is generally coaxial with the driving shaft (FR-2415211).

20 In FR-2401331, there is described an automatic device for adjusting the pitch of the driving propeller of a wind generator by means of rollers or rods engaged in grooves forming cams arranged in plates carried by each of the shafts of the blades. The blades can also
25 be actuated by "eccentrics" driven against the action of springs by flyweights bound in rotation to the wheel. In the literature there are also found means incorporating "eccentrics" driven by the wind itself (FR 2415211) or by a central device controlled by means
30 of the wheel and whose translation can be provided for example by means of a watt regulator (FR 2401331) or a screw-bolt system reacting to the difference in speed between that of the wheel and that of a motor rotating at a reference speed (FR 2313576).

35 The device according to the invention makes it possible not only to solve the problem of violent winds but it also makes it possible, by means of a large pitch in the absence of wind, to facilitate the starting of the propeller, this pitch then reducing

down to an optimum value and then increasing if the wind increases, or even to become feathered in the case of gusts.

Basic information on wind generators will
5 furthermore be able to be found in the French patent FR 2.500.077.

Without going into detail, it is recalled briefly that another type of wind generator, like the one that is the subject of the invention, is directed towards
10 the wind by a fin; the movement is transmitted to the base of the wind generator by a universal joint and a shaft which drives flyweights rubbing on a cylinder.

The present invention relates to the regulation of power of a wind generator propeller coupled to a
15 generator by giving the blades of this propeller (there are at least two blades, for example two or four) a profile such that the efficiency of this propeller varies inversely with respect to the variation of the energy of the wind. For this purpose, the torque/speed
20 characteristics of the propeller are determined such that the operating point starts to move towards the zones of low aerodynamic efficiency when the speed of the wind approaches the value for which the generator reaches the maximum power compatible with safety as
25 divulged in the French patent N° 1.553.046.

In this patent FR-1553046, the essential part of the regulation is acquired without movement of the blades thus resulting in a greater stability of the regulation than in the usual variable pitch systems
30 which reduce the power by increasing the angle setting; the system described in the French patent N° 1.553.046 added an important improvement by being provided with a system of centrifugal flyweights arranged in such a way as to reduce the setting angle of a part of the blades
35 when the speed of rotation tends to increase, it being also provided with a system of stops and means of return against these stops which mechanically define the initial angle setting and the optimum operational angle setting up to the nominal speed. Generally the

blade is pivoting about a spindle and drives, by the intermediary for example of an arm, the end of a return spring which tends to maintain the blade in contact with a fixed stop which defines the initial angle
5 setting. The French patent N° 1.553.046 describes a certain type of spring assembly, an assembly which, whilst being very correct, does not have the advantages of the present invention, also incorporating a system of flyweights and arms but with an original arrangement
10 of at least one spring.

In general, the blade or a part of that blade, can constitute the centrifugal flyweight system. It is also possible to envisage mounting the flyweight at the end of an arm integral with the blade, or part of blade.
15 The arm bearing the flyweight and the arm for attachment of the spring can then form one and the same bellcrank lever.

A variant provides a blade, or part of blade, integral with a heel-piece arranged to drive the mobile
20 end of a second spring, this end being retained by a second fixed stop when the blade or part of blade has rotated through a certain angle. In this case, the first stop corresponds to an initial angle setting which provides a high starting torque and the second
25 stop (main stop) corresponds to the optimum operational angle setting up to the nominal speed. This second spring can be attached to a secondary arm which pivots about the axis of rotation of the blade. This spring brings this secondary arm into contact with the first
30 stop. Eventually, this second spring bears by its free end against the second fixed stop; the heel-piece is then disposed in such a way as to drive this end directly after the rotation of the blade.

Figures 1, 2 and 3 are taken from the French
35 patent N° 1.533.046 and illustrate the techniques that the present invention improves.

Figure 1 shows a blade element and the components of the forces which result from the action of a wind W of angle beta on the blade element whose angle setting

angle is α ; dP is the lift proportional to the angle of incidence i which is the difference between β and α ; if the wind generator is lightly loaded, the low values of dF correspond to low values of dP , and consequently to low values of i ; the variations of angle setting α substantially follow those of the wind angle (β); the inevitable variations of incidence result in large variations in the forces applied to the blades of propellers, resulting in heavy wear of the pitch variation mechanisms.

In figure 2, the blade 1 is provided with a pitch variation mechanism constituted by a bellcrank lever 2 integral with the blade and mounted such that it pivots about the axis 3 perpendicular to the axis of rotation of the blade. At one of the ends of the lever 2, there has been fixed a flyweight 4 and at the other end there has been attached a return spring 5. A stop 6 determines the initial angle setting α of the blade.

In figure 3, in addition to the main lever 2, connected to the blade 1 and returned by the spring 5, there is a second lever 7 mounted on the same axis 3 as the lever 2 and returned by a spring 8 into contact with a stop 10. On the lever 2, there has been fixed a heel-piece 9 disposed in such a way as to be able to drive the lever 7 against the action of the spring 8 when the lever 2 has pivoted through a certain angle. As indicated in FR 1.553.046, the spring 5, rather flexible, is the starting spring and the stop 6 corresponds to an initial angle setting sufficiently large to ensure a high starting torque. At half-speed the angle setting α occurs again corresponding to the main stop 10. This angle setting remains constant up to the nominal speed beyond which the angle setting is reduced and the main pre-stressed spring 8 is put under load.

In this French patent N° 1.553.046, the springs used work in tension and the details of this patent are

specifically limited to these tensions. In the present invention, it has been discovered that it could be very advantageous, subject to there being some original devices, to use either at least one system with at least two springs arranged differently from the arrangement in figures 2 and 3 (see figure 4) or even more advantageously at least one spring working not in tension but in compression (see figure 5). But, according to the invention, it can also be very advantageous to use a mixed technique combining both the devices of figures 4 and 5, this mixed technique being illustrated in figure 6.

In fact it is appropriate to emphasize that the regulation is always carried out in the condition of aerodynamic stalling, a system in which the resultant dR (see figure 1) varies very little and the variation in angle setting necessary for this regulation is very small. Because of this, various imperatives must be taken into account. In fact, the angle dR with the perpendicular to the chord of the profile never exceeds, in a forward direction, a value of about ten degrees such that it suffices to reduce the angle setting by an angle $(\alpha + 10^\circ)$ in order to be assured that the driving component becomes negative. The regulation is finally obtained not by variation of dP but by variation of the angle dR with the plane of rotation.

In brief, due to the mechanism according to the invention, at least one flyweight system acts against the return force of the spring or springs when the speed of rotation tends to increase and causes a reduction of the angle setting. Furthermore, the devices according to the invention make it possible to provide an initial angle setting that is very much higher than α in order to ensure a very high starting torque.

Another advantage of the devices according to the invention is to envisage the regulation, no longer with the totality of the blade, but with one element only,

for example with the ends of the blades which are aerodynamically more active.

The succinctly schematized figure 4 shows a first aspect of the invention. It describes a device which
5 comprises at least two blades 11. Each of them is integral with a bellcrank lever 12 (or a bellcrank arm or any equivalent means), each of the bellcrank levers being mounted such that they pivot about an axis 13 (the figure here showing a system with two blades and
10 therefore with two axes) these axes are perpendicular to the axes of rotation of the blades. At each of the ends of the levers 12 is fixed a flyweight 14 and at the other end of each lever 12 is attached a return spring 15, each of the springs being attached according
15 to the invention on the one hand to a flyweight 14 integral with one of the blades and, on the other hand, to the end of a lever 12 integral with another blade. Thus for example, in figure 4 representing a system with two blades, comprising two levers, two flyweights
20 and two springs, the two springs face each other, each one being attached, on the one hand, to each of the two flyweights which face each other symmetrically with respect to a plane perpendicular to the two bellcrank levers and each of these two springs being attached, on
25 the other hand, to the opposite end of the lever to that which connects the spring to the flyweight, this end, called opposite, in fact being the end of the lever connected to the other flyweight. In other words, each spring connects the flyweight attached to a lever
30 to the end of the other lever attached to the other flyweight.

Moreover, a fixed stop 20 corresponds to each lever, in this case therefore at least two stops 20 which determine the initial angle setting α of each
35 blade. An arrow F' is the indication of the direction of the wind W and the other arrows F indicate the separation of the flyweights, the arrows f indicating the rising of the blades. The levers lower by the centrifugal effect applied to the flyweights in

rotation under the effect of the wind whilst the springs lengthen and apply tension in the opposite direction on the flyweights, thus maintaining the correct functioning of the wind generator.

5 In this case there are therefore at least two blades (preferably two blades) with direct action of one blade on the other with, furthermore, the following two advantages:

- Stabilization and damping on the one hand: there is
10 in fact a minimum amount of vibration and noise due to the direct damping effect of the force differential on the blades due to the wind differential between the blade in the high position and the blade in the low position and the passage in front of the mast of the
15 blade in the low position.

- Absence on the other hand of linkage and of wearing part, which is a considerable advantage in comparison with the devices of the prior art.

Figure 5 shows a second variant of the invention,
20 namely a device functioning with the help of a spring that is compressed and not under tension.

In figure 5, the device according to the invention comprises a set of at least two blades 21 (preferably two blades), each integral with a bellcrank lever 22
25 (in this case preferably two bellcrank levers 22); each bellcrank lever is connected to a flyweight such as 24. Each of these bellcrank levers pivots about an axis 23 perpendicular to the plane of the blades or of the bellcrank levers. According to the invention, the
30 improvement consists not in using a spring connected on the one hand to a flyweight and on the other hand to an end of a bellcrank lever, a bellcrank lever other than the one which is connected to the flyweight, but in using a spring functioning "in compression" and not in
35 tension, this spring being connected at its base to at least two stops 30 and this spring being connected at its top to a fixed nut 26. In this variant of the invention, when the levers lower by centrifugal effect applied to the flyweights rotating under the effect of

the wind, thus driving the ends of the bellcrank levers upwards, the spring is compressed and applies an action in the opposite direction on the flyweights, thus maintaining the correct functioning of the wind
5 generator.

The two flyweights, in figure 5, separate as indicated in the figure (arrows F) with a rising of the blades (arrows f), the arrows f' indicate the direction of the compression or decompression. The arrow F'
10 indicates the flow of the wind W.

In this case there is therefore angle setting by compressed spring which in particular furthermore provides two advantages:

- On the one hand an effect of stabilization and
15 damping, as a mean position resulting from the forces applied by all of the blades, and by the presence of this compressed spring, with a minimum of noise and vibration.
- On the other hand, the absence of linkage and wearing
20 part.

It is also possible to add a third non-negligible advantage: the regulation of the speed of rotation is carried out very easily by simple variation of the initial or "off load" compression of the spring.

Figure 6 shows what was referred to above as the
25 "mixed technique". This figure 6 is identical to figure 5, that is to say it is characterized by the presence of at least one spring 25 operating in compression, but it furthermore comprises at least two springs 15
30 identical to those which are shown in figure 4. In this case the invention combines the advantages of the two figures 4 and 5. The function of the spring 25 is mostly a damping action. The function of the springs 15 is mostly a stabilization function. The combined action
35 of the two types of support results in:

A major damping function of the springs such as 15. A major stabilization function in the average position of adjustment of the central spring (functioning in compression).

This mixed technique offers increased sensitivity of the regulation by minimization of the stiffness of said central spring.

5 It will therefore be noted that one of the characteristics of the present invention is essentially the fact of having at least one pair of blades, certain elements of one blade being connected to the elements of the other blade. In particular, each spring connects the flyweight attached to a lever to the other end of
10 the other lever attached to the other flyweight as described above. This type of device does not appear in other improvements of wind generators described in particular in DE 3115202 or in DE 805388 or in FR-A-2817298.

15 In these documents, the blades are independent of each other and are not linked to each other for example by the presence of a return spring of one blade connected to an element of another blade, or by the presence of a flyweight being connected to a flyweight
20 of another blade.